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A Study on the Vertical Distribution of Respiratory Activity of a 40-year-old Stand of *Chamaecyparis obtusa****

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40年生ヒノキ林の呼吸速度の垂直分布

大畠誠一・山倉拓夫・斉藤秀樹・四手井綱英

CONTENTS

RÉSUMÉ

The forest community has a large ratio of non-photosynthetic organs to photosynthetic ones compared with other plant communities. Upon first glance, this ratio seems to be a burden to photosynthetic organs concerning the dry matter production in plants. As the greater part of woody organs in tree is made up of dead cells, the weight of the woody organs is not as much a burden to photosynthetic organs as it seems.

To examine the respiratory activity of the respective parts of tree organs, the vertical distribution of the amounts of respiration in leaves, branches and stems of a 40-year-old stand of *Chamaecyparis obtusa* plantation forest was investigated during one growing season.

The distribution pattern of respiration in leaves at determined layers was similar to that of leaf density. On the other hand, the distribution patterns of respiration in

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the stem and branches were not similar to those of weight. A close correlation was found between the distribution patterns of respiration of woody organs, i. e. the stem or branches, and that of the growth of these organs in a current year. Namely, the respiratory mechanism of woody organs has a mechanism favourable to the dry matter production of a forest community.

要　　旨

森林群落は他の植物群落に比べて非同化部分の量（C）と同化部分の量（F）との比，いわゆるC/F比が一般に非常に大きい。C/F比が大きいことは同化部分に対して呼吸消費部分の負荷が大きいことを意味し，生長という点からは能率が悪いことになる。しかし，樹木の場合，Cの大部分は枯死細胞から成り，Cの重量がそのままFに対して負荷することにはならない。そこで，非同化部分の呼吸速度に与える要因を検討する必要がある。

ここでは，40年生ヒノキ人工林の幹，枝及び葉の呼吸速度の垂直的変化を樹木の生育期の一時点で調べ，その変化の要因を検討した。

葉の呼吸速度の垂直分布の型はほぼ葉の量の分布と似た型を示し，枝及び幹で，それぞれの器官の重量分布とは異なった型を示した。幹，枝の呼吸速度の分布型は，当年生長した量と密接な関係が見い出された。この結果は，森林群落が大きな非同化部分を持つけれども，当年以前に蓄積した部分の呼吸速度が著しく小さいので，非同化部分全体の呼吸消費量はそれほど大きな量でなく，群落全体の物質生産には有利な機構を持つことが見い出された。

INTRODUCTION

The well known equation for production of dry matter by forest trees was first formulated by Boysen Jensen as follows;

annual net increment=gross production−(loss of roots, branches, leaves, barks and fruits+loss of dry matter by respiration in roots, stems, branches and leaves).

Later, Möller and others[1)2)] tried to determine the quantities of the equation in beech forests of Denmark and in tropical rain forests of Ivory Coast.

One of the big quantities in the equation or in the balance sheet of dry matter production is the loss of dry matter through respiration of non-photosynthetic organs. But, a serious difficulty still seems to remain in the estimation of total respiration of non-photosynthetic organs, because the respiratory activity of trunk and branch is influenced by many factors.

Only a few attempts have, however, been made in the past to study the factors influencing the rate of respiration in woody organs. Möller[1)] et al. (1654) mentioned that the respiratory activity of stems and branches depended not only on the surface area but also on the width of the annual rings, and attempted to explain the mechanism of respiration of woody organs in relation to the thickness of bark, through which the gas exchange took place. Löhr (1969)[3)] stated recently that the respiratory activity of trunk and branch depended mainly on three factors : diameter of the stem-sections or branch-sections, nutritional condition and temperature as well as the season

in temperate climate zones. The respiration in wood decreases rapidly inwards since the physiological activity of wood is mostly concentrated in the thin cambial zone and most of the cells in the older parts of the stem or branch are dead (Goodwin & Goddard 1940[4]).

To obtain a more reasonable relationship between the amounts of stem, branches and leaves and those of respiratory consumption, the vertical distributions of them were compared respectively. As mentioned above, the respiratory rate of woody organs is affected so many factors that it seems relevant to make the factors clearer. As the first step for this purpose, factors dealing with the temperature and the seasonal changes were not taken into account in this study.

In preparing this pater, the authors are especially indebted Dr. Toshio TSUTSUMI of Kyoto University. Aid for field work by the members of the Laboratory of Forest Ecology of Kyoto University is also sincerely acknowleged.

MATERIAL AND METHODS

The stand investigated aged 40 years is situated southwestwards about 30km from Lake Biwa, Shiga Prefecture, on the western flattish slope of Mt. Watamuki, on which slopes *Chmaecyparis obtusa* plantation patches of various aged forests occupy the greater part (Fig. 1). Climate records indicate comparatively mild climate, with a mean annual temperature of 13.6°C, mean annual precipitation of 1550mm, and maximum snow depth of about 50cm in winter. Although the thinning had been carried out about 10 years before, the stand crown was fully closed at the time of investigation. Mean relative light intensity was 2.3% at 1.3m above the ground.

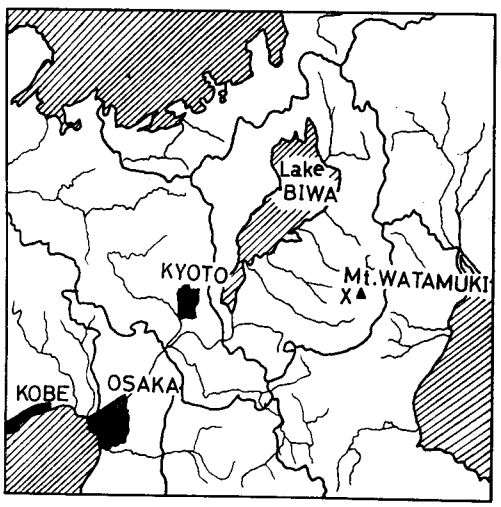

Fig. 1. Map showing location of sample plot investigated.

The investigation was undertaken during 4 days in late August of 1968. The census of D. B. H. was taken of all trees in the sample plot of 20m x 25m in size. From the outside of the sample plot, seven trees were felled and the census of tree height and depth of crown, etc. were taken. The stem boles, branches and leaves of each felled shoot were separately weighed by means of stratified clip technique—the depth of a stratum was 1m. Small samples of each part of respective tree components were oven dried at 80°C, and conversion factors from fresh weight to dry weight were determined. The stem volume, its annual increment and increment of current year were calculated by stem analysis. To obtain branch volume and its increment of horizontal layers, four trees were selected from the felled trees, and two or four sample branches

were taken out from each layer of each tree. Measurements of increment of branch were carried out like the stem analysis.

The estimation of primary productivity was made with an indirect method using allometric relations based on the sample trees, which have been employed by many investigators[5)6)] in Japan.

The rate of respiration of the tree organs was determined with Warder titration method, which was the same one empleyed by Yoda et al. (1965)[7)] and Yoda (1967)[8)]. Fifteen containers of eight different sizes were prepared for sample of various tree organs and of various sizes, which were made of cylindrical galvanized tin containers. For the samples of the stem and the branches, seven containers which differed in diameter from 10cm to 60cm with a height of 60cm were used, and eight similar containers (about 20cm in diameter, 20cm in height) were used for leaves. A 0.5N KOH solution was enclosed in the container with the sample to absorb carbon dioxide for about two hours. The surface area of the KOH solution in each container was about 20% or more than that of the base of the container to establish more efficient absorption of CO_2[9)], so that the amount of KOH solution, of which 25ml was poured into one petri dish, was changed by differing the number of petri dishes according to the base surface of the container.

After the CO_2 absorption, the KOH solution in petri dish was poured into a 50ml plastic bottle. Then the bottles were brought back to the laboratory, where the determination of the amount of CO_2 absorbed by the solution was made by titration.

Measurements of respiration were practied under the natural conditions on the forest floor. Maximum-minimum thermometers were used to estimate the mean temperature in the container during the period of enclosure, and respiratory rates obtained were converted to the corresponding values at 25°C on the assumption that Q_{10} was equal

Table 1. Respiraotry rate in leaves at each layer (r_L), leaf density in fresh weight (W_L) and amount of respiration in leaves at each layer (R_L) on three sample trees.

layers (m)	No. 1			No. 2			No. 3		
	W_L^*	r_L^{**}	R_L^{***}	W_L^*	r_L^{**}	R_L^{***}	W_L^*	r_L^{**}	R_L^{***}
17.3–18.3	0.03	—	—						
16.3–17.3	1.92	63.8	122.6						
15.3–16.3	7.85	58.8	461.4						
14.3–15.3	9.28	38.3	354.9	0.39	101.6	40.5	1.27	—	—
13.3–14.3	11.49	43.0	494.1	4.49	68.1	305.6	5.00	65.0	324.7
12.3–13.3	9.49	25.5	242.0	4.84	42.7	206.9	8.94	35.5	317.2
11.3–12.3	6.75	12.5	82.2	2.29	18.5	42.3	6.94	63.8	442.6
10.3–11.3	2.88	25.0	71.9	0.90	23.1	20.7	3.22	24.0	77.2
9.3–10.3	1.41	25.0	35.4	0.31	17.3	5.3	2.06	23.0	47.2
8.3– 9.3	0.62	—	—	0.16	—	—	0.64	20.0	12.7
7.3– 8.3	0.38	—	—						

*: kg/m/sample tree ; **: mg CO_2/Kg/hr. at 25℃ (fresh weight basis) ;
***: mg CO_2/hr./sample at 25℃.

to 2.0.

As materials for measuring the rate of restpiration, six sample trees for the stem, three sample trees for the branches and leaves respectively were used from the felled trees. For measuring the rate on stem, the sections of stem were about 25cm in length, and for branches one representative branch was selected from each layer, on which rate was measured whole. As leaf sample, 40g of leaves in fresh weight from each of each sample tree were used.

As the measuring of respiration was finished within about six hours, the rise of respiration after traumatic stimulus seemed not to occur, because the length of duration of normal respiration on coniferous trees is respectively long.[10]

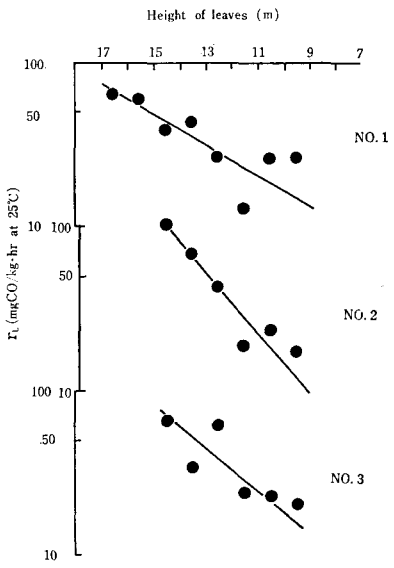

Fig. 2. Distribution pattern of rate of respiration of leaves in fresh weight in relation to height of leaves on three sample trees.

RESULTS

1) Vertical distribution of respiratory rates in leaves

As shown in Table 1, the respiratory rate of leaves per kg in fresh weight at the highest stratum was about 100mg CO_2 per hour at 25°C, and that at the lowest stratum was about 20mg CO_2, i. e. the latter was one-fifth of the former. The respiratory rate decreased gradually with decreasing layers in the crown from top to bottom. This decline was exponential as shown in Fig. 2. The tree height and depth of crown in tree were 17.7m and 10.1m in No. 1, 15.1m and 6.1m in No. 2 and 16.4m and 6.7m in No. 3 respectively. The larger the tree height or the depth of crown, the steeper the gradient of regression line was observed. According to the results of three sample trees, the larger the tree height or depth of crown, the higher the rate of respiration of leaves was observed. In other words, each tree in the stand has differing amounts of leaves with different respiratory activity, respectively, according to tree height.

As for the exponential decline of the respiratory rate in leaves, no reasonable interpretations are available at present.

An equation of the relation between the respiratory rate(r) in leaves of *Fagus crenata* on the basis of weight or area at a certain horizontal stratum and relative light intensity (I/I_0) was reported by Yoda et al. (1968), which was

$$I/I_0 = a\ e^{br},$$

where a and b were constants. The relation obtained in *Chamaecyparis obtusa*, on the other hand, was not satisfied by the equation. This discrepancy seemed to be caused by the difference of life length of the constituent leaves. The life of a leaf on deciduous trees is short, for instance, the life length of *Camptothea acuminata* was one or

two months in spring and two or three months in summer.[12] In estimation based on litter fall, the life length in a leaf of *Chamaecyparis obtusa* in a concerned stand was about six years.

The rate of respiration of the leaves of evergreen trees is highest when sprouting in spring, decreases gradually, and then increases again a little in the following summer. The maximum value in respiratory rise in each summer, however, gradually decreases with the years. Such a cycle in the respiratory rate was reported on leaves of *Ilex pedunculosa*,[13] *Cryptomeria japonica*[14] and *Pinus Thunbergii*.[15]

Table 2. Respiratory rate in branch at each layer (r_B), branch density in fresh weight (W_B) and amount of respiration in branch at respective layers (R_B) in three sample trees

layers (m)	No. 4			No. 5			No. 6		
	W_B^*	r_B^{**}	R_B^{***}	W_B^*	r_B^{**}	R_B^{***}	W_B^*	r_B^{**}	R_B^{***}
16.3–17.3	0.16	50.9	8.3						
15.3–16.3	1.90	16.9	32.2				0.05	51.8	2.8
14.3–15.3	4.15	11.7	48.6				1.54	25.5	39.2
13.3–14.3	5.85	7.0	40.8	0.07	–	–	5.10	–	–
12.3–13.3	6.45	2.2	14.1	1.25	25.5	31.9	8.60	14.3	123.0
11.3–12.3	2.97	4.2	12.4	2.80	8.9	24.8	11.50	13.2	151.2
10.3–11.3	5.00	2.3	11.7	2.97	12.0	35.6	9.15	3.6	32.8
9.3–10.3	2.70	–	–	3.50	12.5	43.7	6.00	–	–
8.3– 9.3				1.80	4.5	8.2	8.50	0.7	5.9
7.3– 8.3				1.62	5.7	9.2	1.68	–	–

*: kg/m/sample tree ; **: mg CO_2/kg/hr. at 25℃ (fresh weight basis) ;
***: mg CO_2/hr./sample at 25℃.

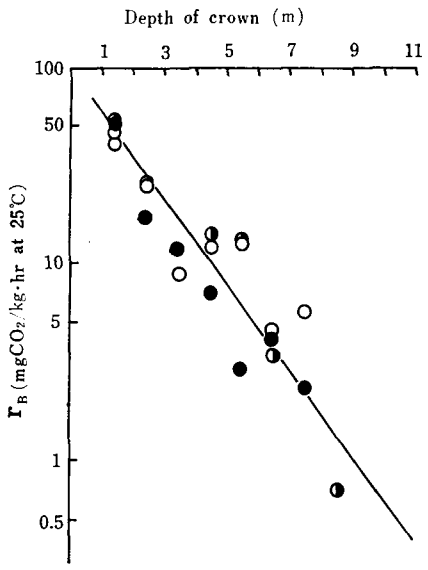

Fig. 3. Respiratory rate in branches (fresh weight basis) and depth of crown from tops of three sample trees.

The difference in the patterns of vertical distribution in the respiratory rate in leaves between deciduous (*Fagus crenata*) and evergreen (*Chamaecyparis obtusa*) trees would be ascribable to the difference in the life constitution of the leaf itself.

2) Vertical distribution of respiratory rates in the branch

The respiratory rate of branches per kg in fresh weight was about 50 mg CO_2 per hour at 25°C at the highest horizontal stratum and 0.7~5 mg at the lowest stratum (Table 2). This great difference in respiratory activity would be

ascribable to the difference of age of branch in each stratum. The branches at thehighest horizontal stratum are one to five years old, and those at the bottom are thirty to thirty-five years.

As seen in leaves, the change in respiratory rate of the branch on the basis of weight was recognized as an exponential decline. The gradient of the regression line was, however, steeper than that in leaves as shown in Fig. 3. It seemed that the different features of gradient of the regression line on the respiratory rate per weight between leaf and branch would be ascribable to the amount of living cells contained in each organ, because a great part of the branches was made up of dead cells which was evaluated by weight. If the amount of living cells in a branch be sustained by the amount of leaves on the branch, and if the respiration of a branch be relative to the amount of living cells in a branch, there may be a certain correlation between the respiratory rate of the branch on the basis of fresh weight (r_B) and the ratio of the amount of leaves in fresh weight to that of the branch (W_F/W_B). A close correlation was recognized between r_B and W_F/W_B, as shown in Fig. 4. The regression line in Fig. 4 can be expessed in the following equation;

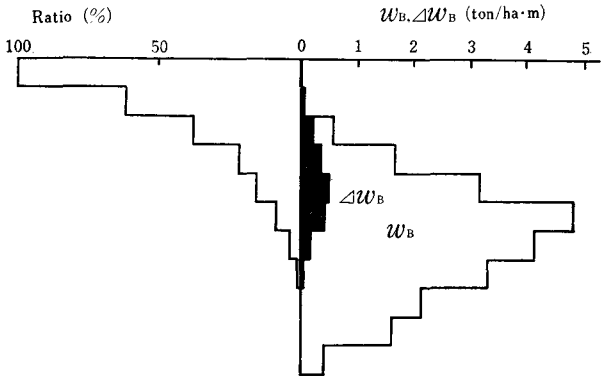

Fig. 4. Respiratory rate in branches (fresh weight basis) and ratio of amount of leaves (fresh weight) to branches (fresh weight).

$$r_B = a \cdot W_F/W_B \quad \text{or} \quad r_B \cdot W_B = a \cdot W_F,$$

where a is constant.

3) Vertical distribution of respiratory rate in the stem

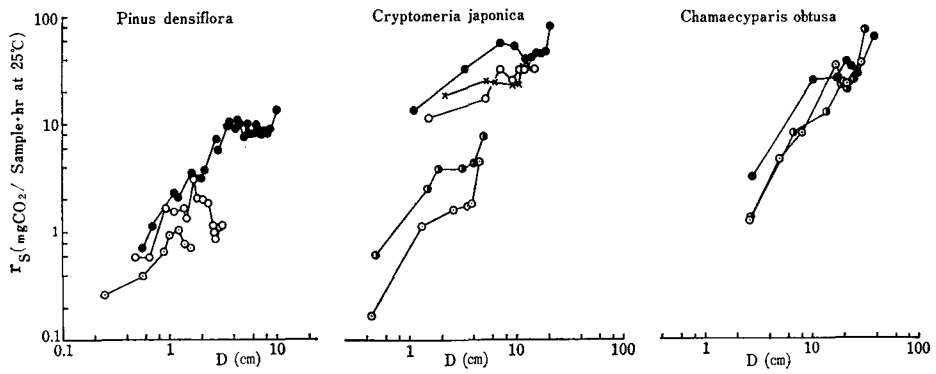

Fig. 5. Diameter and amount of respiration of stem sections, cut off in similar lengths. *Pinus densiflora*: 20cm in length, respiration measured by gas analyzer; *Cryptomeria japonica*: 25cm, Warder titration method; *Chamaecyparis obtusa*: 25cm, Warder titration method.

Table 3. Respiratory rate in stem (r_S) at each layer and diameter at each part of six sample trees

layers	No.1		No.2		No.3		No.4		No.5		No.6	
	r_S^*	D**	r_S^*	D**	r_S^*	D**	r_S^*	D**	r_S^*	D**	r_S^*	D**
17.3–18.3	—	—										
16.3–17.3	15.32	3.4					16.45	2.6				
15.3–16.3	—	—					12.75	4.8			13.60	2.7
14.3–15.3	9.25	9.8	38.33	1.2	12.75	2.6	7.84	7.8			—	—
13.3–14.3	—	—	19.94	3.8	14.95	6.4	—	—	—	—	—	—
12.3–13.3	—	—	—	—	—	—	—	—	26.27	3.6	10.77	9.5
11.3–12.3	6.35	17.0	7.81	8.0	6.33	13.0	—	—	—	—	—	—
10.3–11.3	—	—	2.84	9.1	—	—	—	—	—	—	—	—
9.3–10.3	—	—	1.17	11.2	—	—	9.16	16.3	—	—	7.11	16.3
8.3– 9.3	8.54	22.2	—	—	6.43	18.2	—	—	3.64	10.7	—	—
7.3– 8.3	—	—	—	—	—	—	—	—	5.13	11.7	6.69	20.0
6.3– 7.3	—	—	—	—	3.75	20.2	3.98	19.1	—	—	—	—
5.3– 6.3	5.76	26.3	—	—	—	—	—	—	3.08	13.7	4.03	22.7
4.3– 5.3	—	—	0.68	15.2	—	—	4.36	20.5	—	—	—	—
3.3– 4.3	4.38	29.1	—	—	2.96	23.0	—	—	3.58	15.2	—	—
2.3– 3.3	—	—	—	—	—	—	—	—	—	—	3.56	25.7
1.3– 2.3	—	—	0.96	17.6	—	—	—	—	5.11	16.2	—	—
0.3– 1.3	—	—	—	—	—	—	—	—	0.78	18.0	—	—
0.0– 0.3	5.31	35.0	1.61	20.3	2.63	29.6	3.70	27.0	2.96	19.0	3.72	36.0

*: mg CO_2/kg/hr. at 25℃ (fresh weight basis) ; **; cm.

Since it had been detected by Möller et al. (1954) that the rate of respiration in the stem on the basis of weight was proved to decrease with increasing diameter, it was confirmed by many investigaters.

The same relation was recognized in the stem of *Pinus densiflora* and *Cryptomeria japonica*, and also *Chamaecyparis obtusa* studied here as shown in Table. 3. The relation between diameter and repiratory rate in each sample of stem sections, which were cut off in similar lengths, is shown in Fig.5 with the results of *Pinus densiflora* and *Cryptoemria japonica*. If the gradient values of the regression line be equal to 2.0, 1.0 and 0.0 in Fig. 5, then the respiration in the stem may be expected to be proportional to the volume, surface area or no relation with diameter respectively.

There are two features in the respiration in stems in Fig. 5. One is the pattern of changes from the top to the bottom in a trunk. The respiration increases with increasing diameter till a certain level on the upper part of the trunk, remains constant at a certain magnitude and again increases at the thickest part near the root. The other

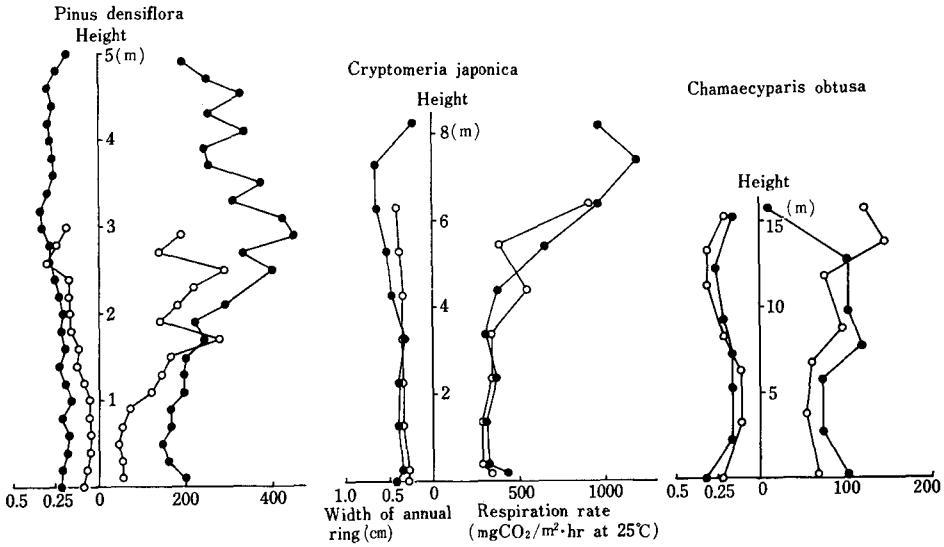

Fig. 6. Width of annual rings in a current year and respiratory rate in stem per square meter at respective height of stem.

is the difference of respiration among sample trunks.

As already recognized by Möller et al.[1], there is a certain relationship between the respiratory rate on the surface area basis and width of annual rings. The relation, here, between the vertical distribution of current annual rings and that of the respiratory rate per square meter was represented. The interrelation between the right and left sides of the diagram on the three species seems to have a close correlation as shown by the six samples of three species in Fig. 6. Namely, the amount of respiration in the stem is expected to have a close correlation wtih the growth of current annual volume (Δv_S). If the volume of the stem be proportional to the weight, the growth of weight in a current year (Δw_S) must be expected to have the same correlation as the growth of volume in a current year.

The relation between the amount of respiration in the stem of sample sections (r_S) and Δv_S, and that between r_S and Δw_S are shown in Fig. 7 and Fig. 8. The sourse of data is the same as that of Fig. 5, except for *Chamaecyparis obtusa*, which is represented by the three typical examples in Fig. 5 from six sample trees. As expected, close correlations are found between r_S and Δv_S or Δw_S, and it can be approximated by a single $\log r_S \sim \log \Delta v_S$ line whose gradient nearly equals 1.0. Although the observed values are scattered in a wide zone along the regression line, clear systematic trends can be recognized in the distribution of the points belonging to the different trunks and different parts of a trunk, and the segregation of different trunks and different parts of a trunk seen on the $\log r_S \sim \log D$ diagram (Fig. 5) has almost disappeared.

As for the mechanism of respiration in the stem, on the other hand, no reasonable interpretations are available in the relation to CO_2, which is diffused partly from the cambial zone, partly from the youngest woody organs and partly from the older woody organs. Although it is assumption that the respiration in the stem is proportional to

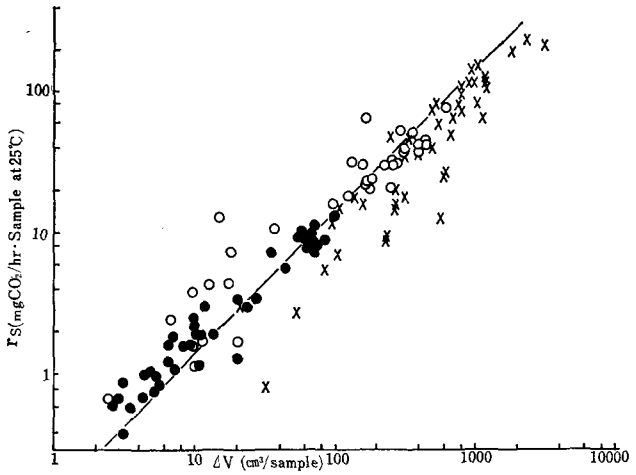

Fig. 7. Respiratory rate per sample sections and growth of volume in a current year. Dots, *Pinus densiflora*; circles, *Cryptomeria japonica*; crosses, *Chamaecyparis obtusa*.

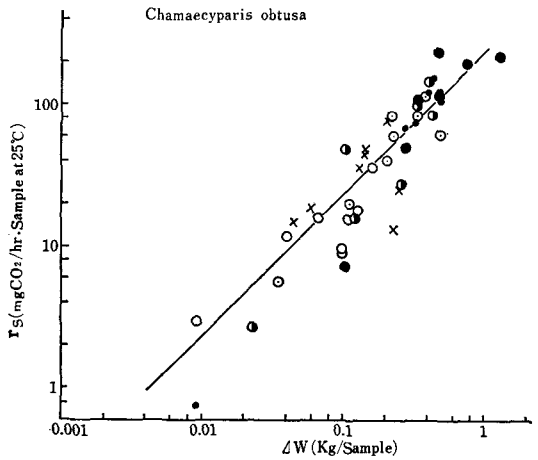

Fig. 8. Growth in weight and respiratory rate per sample stem sections, *Chamaecyparis obtusa*.

the amount of growth volume or growth weight in a current year in the stem at one growing season, this interrelation is thought to be quite important to understand better the mechanism of respiration of woody organs.

From this interrelation it is expected that there is a close relation between the amount of whole growth in one trunk and that of respiration, and that its relation must be proportional to each other. From six sample trees of *Chamaecyparis obtusa* measured at the forest concerned, this relation is represented in Fig. 9. The observed values show that the assumption mentioned above is accurate.

DISCUSSION

1) Relation among the vertical distribution of leaves, that of the branch and that of the respiratory rate of the branch in the stand of *Chamaecyparis obtusa*

From the data of the respiratory rates in leaves at respective horizontal layers of three sample tree, the respiration of leaves at each layer per stand (R_L) was estimated by two methods. A regression line was determined by the relation between the rate of respiration in leaves and the respective height of leaves on the three sample trees (method-I), or from the relation between the rate of respiration in leaves and height put in order at the top layers of three sample trees (method-II) as shown in Fig. 10. The amounts of respiration in leaves of all layers in the stand were 1.81 kg CO_2/ha/hr at 25°C (method-I) and 1.77 kg CO_2/ha/hr at 25°C (method-II) respectively, and the ratio of method-II to method-I was 0.97. As there

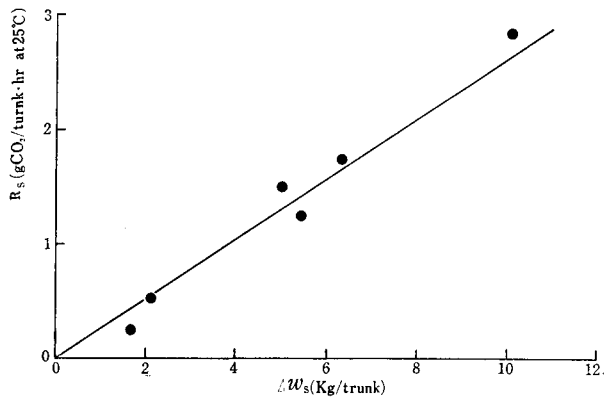

Fig. 9. Growth in weight per sample trunk in a current year and respiratory rate per trunk, *Chamaecyparis obtusa.*

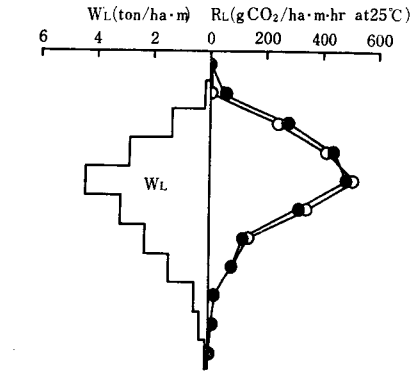

Fig. 11. Vertical distribution of leaf density (dry weight) and vertical distribution of amount of respiration in leaves, *Chamaecyparis obtusa.* Dots, estimated by method-I; circles, estimated by method-II.

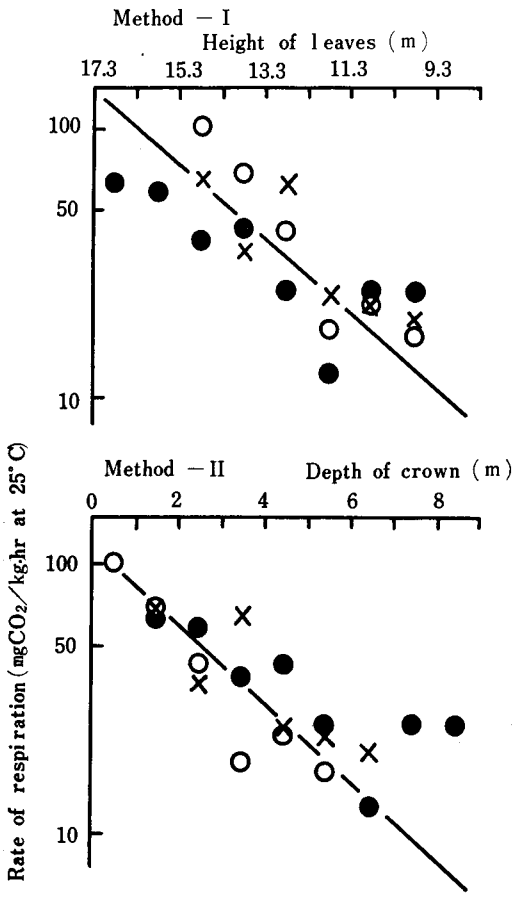

Fig. 10. Respiration rate in leaves and respective height of leaves (method-I), and respiration rate and height of leaves (method-II), (three sample trees)

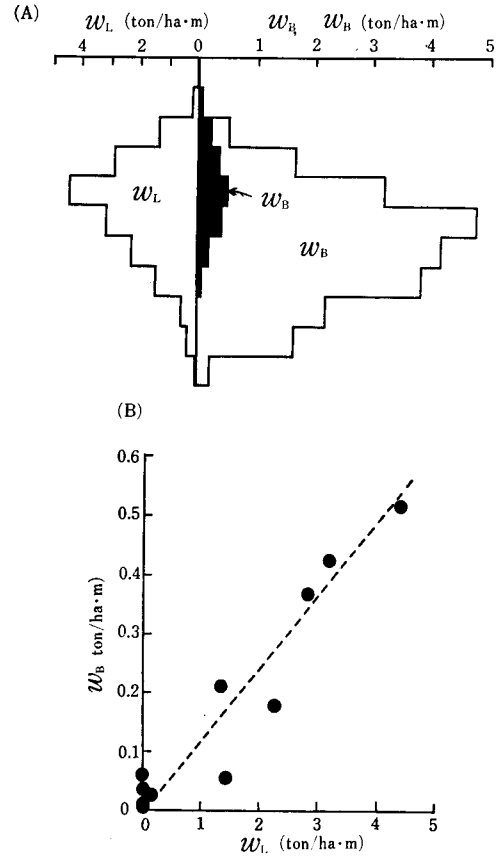

Fig. 12. Vertical distribution pattern of leaf density, branch density and branch growth in dry weight in a current year (A), and relation between leaf density and branch growth in a current year at each layer (B).

was very little difference between the two methods, method-II was used for estimating the respiration in branches of the stand at the respective layers (R_B),

The vertical distribution pattern of leaf density was very similar to that of R_L, as shown in Fig. 11. As seen by the results reported by Saeki,[17] in the *Celosia cristata* plant in a community state, if the respiratory activity be proportional to photosynthetic capacity, it will inversely be expected that the vertical distribution pattern of R_L shows a pattern of vertical distribution of dry matter production in leaves at respective horizontal layers. This was reinforced by actual measurement of branches. A close correlation is recognized between the vertical distribution pattern of leaf density and that of branch growth in dry weight in a current year at each layer (Δw_B) as shown in Fig. 12.

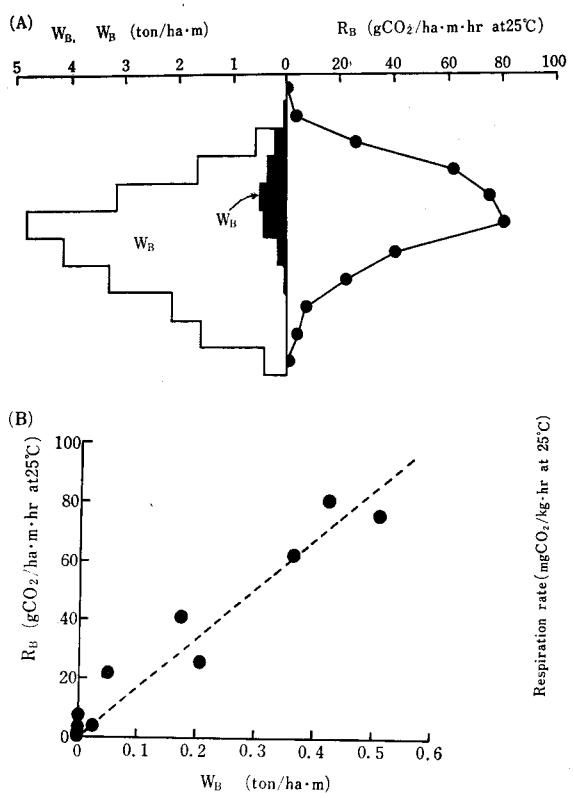

Fig. 13. Vertical distribution of branch density, branch growth in a current year and amount of respiration in branch at each layer (A), and relation between branch growth of dry weight in a current year and amount of respiration at respective layers (B).

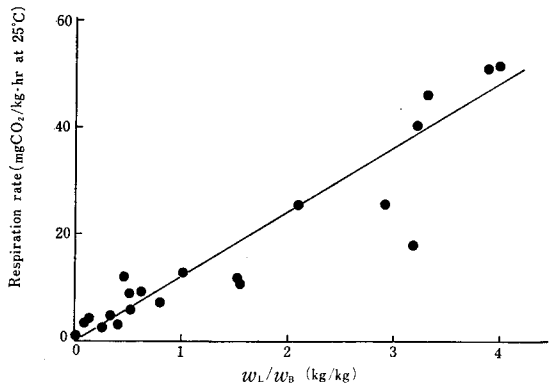

Fig. 14. Vertical distribution of branch density, branch growth in a current year and ratio of $\Delta w_B/w_B$ in *Chamaecyparis obtusa* stand.

As seen in Fig. 12, the vertical distribution curve of R_B and the distribution pattern of branch weight at a horizontal stratum (Δw_B) is quite different from each other, but that curve of R_B is similar to that of Δw_B. The relation between R_B and Δw_B was directly proportional (Fig. 13). The vertical distribution of ratio (%) of $\Delta w_B/w_B$ with decreasing height was exponential as seen in Fig. 14. From the results, it may be expected that the distribution pattern of the respiratory rate in the branch on the basis of weight has an exponential decline from this vertical distribution pattern of the ratio.

The dry matter assimilated by leaves passes through the non-photosynthetic organs and accumulates in these organs in passing, so the relation between the amount of

leaves and growth of non-photosynthetic organs will be expected to have a certain relationship, if he photosynthetic activity and light condition of leaves be constant. As for these relationships between the vertical distribution patterns of leaves and those of non-photosynthetic organs, Shinozaki et al. made quantitative analysis of plant forms and made a hypothetic model, which was called the unit pipe system.[18]

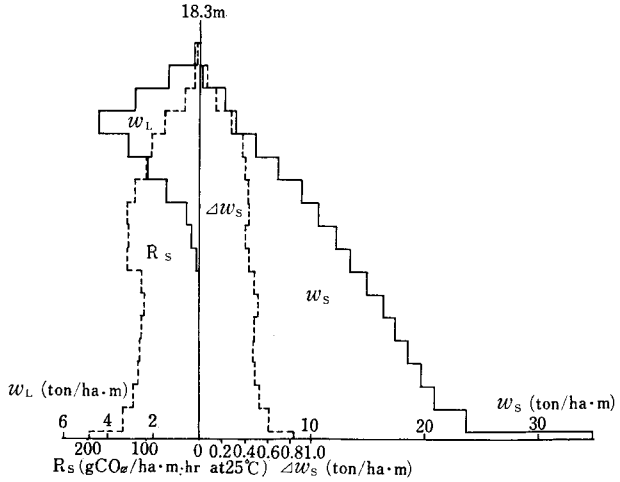

Fig. 15. Profile diagram in *Chamaecyparis obtusa* stand, showing vertical distribution of amount of respiration in stem at each layers (R_S), stem growth of dry weight in a current year (Δw_S), leaf density (w_L) and stem density (w_S) at respective layers.

The proportionality between R_B and Δw_B may be assumed that the amount of respiration of the branch in amount of CO_2 diffused from new pipes made in a current year.

2) The difference between the rate of respiration in the stem and that in the branch in the stand of *Chamaecyparis obtusa*

The vertical distribution pattern of the amount of respiration in the stem of respective horizontal layers (R_S) looks very similar to that of the distribution curve of dry weight in a current year at respective layers (Δw_S) as shown in Fig. 15, which is expected from the relation between the R_B and Δw_B.

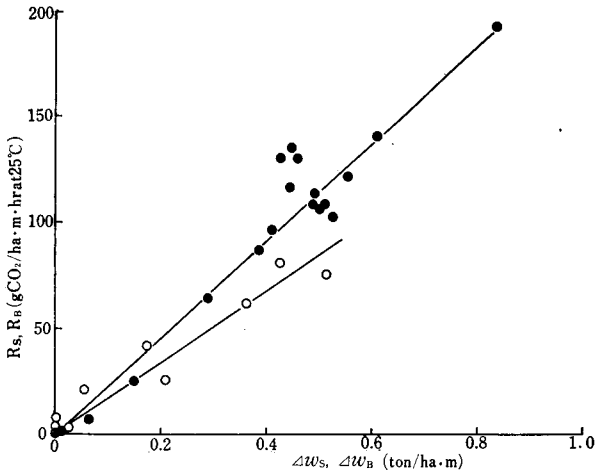

Fig. 16. Direct relation of $R_B \sim \Delta w_B$ and $R_S \sim \Delta w_S$ in *Chamaecyparis obtusa* stand.

The direct proportionality between R_S and Δw_S and between R_B and Δw_B is represented in Fig. 16, in which the gradients of $R_S \sim \Delta w_S$ relation and $R_B \sim w_B$ relation have very slight differences with each other. The value of the ratio of the gradient of the $R_S \sim \Delta w_S$ relation to that of the $R_B \sim \Delta w_B$ was calculated at about 1.3. This difference of respiration in relation to w_S and Δw_B shows a slight contradiction that the amount of respiration in woody organs is proportional to the dry weight in a current year. But, if the next assumption be considered, these differeces will have a certain meaning. Namely, these differences come from the differences in the amount of respiration

diffused from older parts of woody organs. So, it may be inversely possible to know the mechanism of the respiration of the older parts of woody organs by analyzing these differences quantitatively by means of an indirect method.

Anyhow, the vertical distribution pattern of the amount of respiration in woody organs or stems and branches at a certain growing season nearly corresponds to the vertical distribution pattern of the amount of dry weight increment of stems and branches. In other words, the respiratory mechanism of the consumption of woody organs in a forest community, which have a great part of non-photosynthetic organs compared with other plant communities, has a mechanism favourable to the dry matter production of a forest community.

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